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than from Vierordt. The following table gives the results (for the non-normal spectrum) for Prof. Langley, another observer (*a*), and Vierordt, the two former reduced to 1000 for yellow, for the sake of the comparison :

	45	50	55	60	65	70
( <i>a</i> )	151	156	1000	996	208	16
V.	128	370	1000	780	128	22
L.	64	774	1000	141	13	2

These values of Vierordt are for points very near the wave-length at the head of the columns. Vierordt's method was to measure the amount of white light that had to be added to a given color to make the color undistinguishable. Capt. Abney's curve agrees closely with Prof. Langley's.

Prof. Langley has made use of his admirable determination of the distribution of energy in the solar spectrum to obtain the brightness per energy of the different colors. The mean of his three observers, exclusive of himself, is as follows :

Color,	Violet.	Blue.	Green.	Yellow.	Orange.	Red.	Crimson.
Wave-length,	40	47	53	58	60	65	75
Luminosity,	1.6	62,000	100,000	28,000	14,000	1200	1

That is to say, crimson light from the end of the spectrum has to have 100,000 times more energy than green in order to give enough light to enable us to read by it. The absolute work done by that crimson is .001 of an erg, and by the green .00000001 of an erg.

It is not quite plain why Prof. Langley should definitively set down the green as the brightest part of the spectrum, on the testimony of his three observers (he has drawn the curve for only two of them), when he himself, Capt. Abney, and all former observers, beginning with Newton (who says that yellow and orange affect the senses more strongly than all the rest of the prismatic colors together), have considered the brightest part to be in the yellow. Prof. Langley himself suggests that young eyes may be more effective towards the blue end of the spectrum than older ones. C. L. F.

*Ueber die Unterschiedsempfindlichkeit des normalen Auges gegen Farbentöne im Spectrum.* Dr. W. UHTHOFF. Archiv für Ophthalmologie, XXXIV, 4, pp. 1-15.

The sensitiveness of the eye to the change of color produced by a given change of wave-length has been investigated before by Aubert, and more recently by Mandelstamm and by Dobrowolsky. The last two made use of Helmholtz's ophthalmometer without the eyepiece; both plates were lighted up by monochromatic light, and one was then rotated until a difference of color was just perceptible. Dobrowolsky, by means of two Nicols with a quartz plate between them, caused both colors to be of equal intensity, a precaution which is particularly necessary near the ends of the spectrum. They found two points of maximum sensitiveness, one at *D* and one at *F'*; the fraction of its wave-length by which a color had to be changed in order to seem changed was three times as great for green as for yellow or blue, and at the ends of the spectrum it was greater still. B. O. Peirce (*Am. Jour. of Science*, Oct. 1883) obtained a similar curve. König and Dieterici, by the method of mean errors and a different apparatus, got a curve which differs chiefly in rising very

abruptly at the two ends; beyond the wave-lengths  $\mu.43$  and  $\mu.66$  they affirm that absolutely no differences of color are perceptible, but only differences of brightness. Since the method of mean errors is considered by some to be objectionable, Uththoff has repeated these experiments, using the same apparatus, but the method of just perceptible differences. His results resemble very closely those of the last two observers, but they differ somewhat at the ends. The difference is such as to leave it quite undecided whether it is caused by the difference of method or by the individual differences of the eyes experimented upon. Since the principal object of the investigation was to compare the methods, it is a pity that both methods could not have been applied by the same observer.

Peirce found the eye more sensitive to change in the yellow than in the blue; the reverse of that was found by all the other observers, but that is probably because his curve represents the mean of many different observers. He did not detect the changelessness of the two end-positions of the spectrum, but this, Uththoff considers, is because he did not make the colors compared equally bright. The fact, if it is a fact, is of great importance for the theory of color-vision, and it would be well if it could be confirmed by other observers. Uththoff says that the securing of equal brightness is less necessary in the middle of the spectrum than at the ends. This is strange, because, according to Langley's brightness-curves, the brightness is changing most rapidly on either side of the green. Can there be any significance in the fact that the change of brightness and the change of tone are both most rapid in the same part of the spectrum, namely, in the yellow and the blue? C. L. F.

*Experimentelle Untersuchungen über die psychophysische Fundamentalformel in Bezug auf den Gesichtssinn.* Dr. ARTHUR KÖNIG und Dr. EUGEN BRODHUN. Sitzungsber. der König. Preuss. Akademie der Wissensch. zu Berlin, 1888, pp. 15.

Doubting the applicability of the psychophysic law to light illuminations, these experimenters decided to find the differential threshold with various intensities, from the slightest barely perceptible illuminations up to intense brightness, almost glaring. The light was of six different spectral wave-lengths,  $670\mu\mu$ ,  $575\mu\mu$ ,  $505\mu\mu$ ,  $470\mu\mu$  and  $430\mu\mu$ , these answering to the fundamental colors of their visions. König has normal color perception, but Brodhun is green blind. Their rather intricate apparatus and method of observation need not be detailed; the final problem in each observation consisted in adjusting one rectangular patch of spectral light so that it appeared just noticeably darker than another. The intensity of the illumination was varied for each wave-length from 1 upwards to 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000, 20,000, 50,000, and 100,000, and downwards to .5, .2 and .1, the light 1 being the illumination seen by an eye looking through a diaphragm one square millimeter in aperture, at a surface coated with oxide of magnesium, the surface standing at a distance of one meter, and reflecting the light from a glowing platinum surface one-tenth square centimeter in area, standing parallel to it. Grouping all the wave-lengths together, it is found that between intensities 100,000 and 20 there is a very regular slight increase in sensibility, followed by an equally regular and slight decrease, the sensibility between inten-